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G. B. AIRY, Esq., President, in the Chair.

M. Littrow, Director of the Imperial Observatory at Vienna, was balloted for and unanimously elected an Associate of the Society.

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*On new Tables of the Moon's Parallax, to be substituted for those of Burckhardt.* By J. C. Adams, Esq. M.A. F.R.S., &c. &c. (Appendix to the *Nautical Almanac* for 1856.)

(Read before the Royal Astronomical Society on the 14th of May, 1852.)

"The importance of an accurate knowledge of the moon's parallax is very evident. No observation of the moon's place can be compared with the tables, or turned to any practical use, without undergoing a preliminary reduction, of which the amount of the parallax is the most important element. Now the same theory by which the angular motion of the moon round the earth is determined gives likewise the form of the orbit, and therefore the proportion between the parallaxes at different times; hence, as the theory is sufficiently perfect to represent the place of the moon within 10″, it cannot be doubted that it would be competent to give the variations of the parallax within a small fraction of a second, provided the mean parallax were known. To determine this, however, by theory, it is necessary to know, in addition to the elements furnished by observations of the moon's motion, the ratio of the moon's mass to that of the earth. Hence, conversely, if the mean value of the parallax be deduced from corresponding observations of the moon's declination, made at distant points on the earth's surface, one means is afforded of finding the ratio of the masses.

"The most recent determination of the parallax by means of observations of this kind is contained in a paper by Mr. Henderson in the tenth volume of the *Memoirs of the Royal Astronomical Society*, and is founded on his own observations made at the Cape of Good Hope, combined with corresponding observations at Greenwich and Cambridge. In this paper Mr. Henderson compares the parallaxes deduced from observation with those calculated by means of the tables both of Burckhardt and Damoiseau. It is

remarkable that he finds a difference of 1″·3 in the value of the mean parallax, according as one set of tables or the other is employed in the comparison, and not knowing which value to prefer, he adopts the mean of the two for his final result.

" If we consider, however, that the only part of this process which depends on the tables consists in the reduction of the actual parallaxes at the times of observation to the mean value, it is plain that so large a difference in the mean of thirty-four observations can only arise from intolerable errors in the periodic terms of parallax given by one of the two sets of tables.

" The parallax in Damoiseau's tables is given at once in the form in which it is furnished by theory, but that in Burckhardt's tables is adapted to his peculiar form of the arguments, and requires transformation in order to be compared with the former. When this was done, I found that several of the minor equations of parallax deduced from Burckhardt differed completely from their theoretical values given by Damoiseau.

" On further inquiry, I discovered that the difference between Burckhardt's equations of parallax and those of Bürg and Damoiseau had been long since remarked by Clausen, in a comparative analysis of the three sets of lunar tables given in the seventeenth volume of the *Astronomische Nachrichten,* but no notice appears to have been taken of this remark.

" With regard to the parallax, Burckhardt professes to have followed the theory of Laplace; but this agrees very closely with that of Damoiseau, so that errors have evidently been committed by him in the transformation of Laplace's formula.

" These appear to have originated in the following manner :—

" In the formation of Burckhardt's arguments of evection and variation, the *mean* longitude of the sun is employed. Now four of the errors in the coefficients of the minor equations may be accounted for, by supposing him to have erroneously employed the *true* instead of the *mean* longitude of the sun in forming the above-mentioned arguments. In another of these equations, the coefficient is taken with a wrong sign, and in another a wrong argument is employed.

" A strange fatality seems to have attended all Burckhardt's calculations respecting the moon's parallax. In the *Connaissance des Temps* for the year 15 of the Republic, he gives a comparison between the values furnished by Mayer's and Laplace's theories, and he concludes that the error of the former may sometimes amount to 7″.

" But this difference is caused almost wholly by an error in his own transformation of Laplace's expression. In the formation of Mayer's arguments of evection and variation, the *true* longitude of the sun is employed, but Burckhardt appears to have inadvertently used the *mean* longitude instead of it; an error which is the exact converse of the one above noticed with respect to his own tables.

" After examining Burckhardt's tables of parallax, I was naturally led to scrutinise more closely the results of the theories of

Damoiseau, Plana, and Pontécoulant, with respect to the same subject. Although the differences between these were very trifling when compared with the errors of Burckhardt, still they were greater than we had a right to expect, considering the close agreement which existed with respect to the equations of longitude. In the theories of Damoiseau and Plana, the expression for the projection of the moon's radius vector on the ecliptic in terms of her true longitude is required in order to find the relation between that longitude and *the time*, and therefore no pains have been spared to obtain it with accuracy; but in the subsequent operations and transformations necessary in order to deduce the expression for the parallax in terms of the time, the same care has not been employed. In Pontécoulant's theory the time is taken as the independent variable, and, consequently, the analytical expression for the parallax in the form required is obtained immediately, and is developed to as great an extent as the corresponding expression for the longitude; yet in the conversion of his formula into numbers he neglects all the terms beyond the fifth order, so that several of the resulting coefficients are sensibly in error.

"I have endeavoured to supply these defects and omissions.

"In the seventeenth volume of the *Astronomische Nachrichten*, M. Hansen gives the expression which he has obtained for the logarithm of the sine of the horizontal parallax, by means of his new method of treating the lunar theory. I have transformed this expression with the care which its great value deserves, so as to compare it with the results of the former theories

"The agreement thus found between the several theories is most satisfactory, the difference of the separate values of each coefficient and the general mean rarely amounting to a hundredth of a second. There are only two instances in which this amount is much exceeded. One of these relates to the constant of parallax, the value of which, given by M. Hansen's method, is 0″·06 less than the corresponding value found from the same fundamental data by the other methods, and the second relates to the term whose argument in Damoiseau's notation is $t + z$, the coefficient being 0″·146 according to Damoiseau and Plana, 0″·140 according to Pontécoulant, and 0″·181 according to Hansen.

"The values of the constant of parallax which I have deduced from the theories of Damoiseau, Plana, and Pontécoulant, agree perfectly with one another, and from the particular examination which I have given to this subject, I am induced to place considerable reliance on the result. It is possible that M. Hansen's definitive value of the constant may differ slightly from that which he has given in the paper above referred to.

"From the value of the constant of nutation found by M. Peters, it follows that the ratio of the moon's mass to that of the earth is as 1 to 81·5 nearly. Employing this ratio, together with the dimensions of the earth according to Bessel, and the length of the seconds pendulum in latitude $35^{\circ}\frac{1}{4}$, deduced from Mr. Baily's Report on Foster's pendulum experiments, I find the value of the constant of parallax to be 3422″·325.

"Now Henderson, in the paper cited above, has found the value of the constant, by comparison with Damoiseau's table, to be 3422″·46.

"It should, however, be remarked, that what the tables call the parallax is more strictly the *sine* of the parallax converted into seconds of arc. In Henderson's calculations he has taken the tabular quantity to denote the parallax itself, so that the value found must be diminished by 0″·15, in order to obtain the constant of the *sine* of the parallax. Thus the value deduced in this manner is 3422″·31, a result admirably agreeing with that just derived from theory.

"I have carefully transformed the expression for the parallax given by theory, so as to make it depend on Burckhardt's arguments of longitude, and from the resulting formula Mr. Farley has calculated the tables which are appended to this paper. Constants are added to the several equations so as to render them always positive.

"The minor equations of equatoreal horizontal parallax are comprised in Table I.;

"Table II. contains the equation depending on the argument of evection;

"Table III. that depending on the argument of variation; and

"Table IV. that depending on the argument of anomaly.

"The formulæ employed in their construction are the following, in which

E denotes Burckhardt's argument of evection;
V that of variation; and
A that of anomaly;

and the arguments of the minor equations are denoted by their numbers as in Burckhardt.

| | | |
|---|---|---|
| 0″·34 | — | 0″·34 cos (Arg. 1) |
| 1″·73 | + | 1″·73 cos (Arg. 2) |
| 1″·46 | + | 1″·46 cos (Arg. 4) |
| 0″·87 | + | 0″·87 cos (Arg. 5) |
| 0″·71 | — | 0″·71 cos (Arg. 6) |
| 0″·11 | — | 0″·11 cos (Arg. 7) |
| 0″·62 | — | 0″·62 cos (Arg. 8) |
| 1″·81 | — | 0″·05 cos (Arg. 9) |
| 0″·21 | — | 0″·21 cos (Arg. 12) |
| 0″·16 | — | 0″·16 cos (Arg. 13) |
| 0″·14 | + | 0″·14 cos (Arg. 16) |
| 0″·12 | + | 0″·12 cos (Arg. 23) |
| 0″·10 | + | 0″·10 cos (Arg. 25) |
| 36″·81 | + | 37″·22 cos E + 0″·41 cos 2 E |
| 26″·18 | — | 0″·94 cos V + 26″·34 cos 2 V + 0″·16 cos 4 V |
| 55′ 50″·92 | + | 187″·14 cos A + 10″·27 cos 2 A + 0″·64 cos 3 A + 0″·04 cos 4 A |

"In this formula, a few terms have been neglected, the largest of the coefficients of which does not exceed 0″·08.

"The sum of the constants in this formula is 3422″·29, slightly

differing from what is called the constant of parallax, in consequence of the change in the form of developement.

"For the sake of comparison I will here give the formula on which Burckhardt's own tables are constructed, which is as follows:—

| | | |
|---|---|---|
| 0".4 | — | 0".4 cos (Arg. 1) |
| 0".8 | + | 0".8 cos (Arg. 2) |
| 0".3 | + | 0".3 cos (Arg. 4) |
| 0".8 | + | 0".8 cos (Arg. 5) |
| 1".1 | + | 0".8 cos (Arg. 6) |
| 0".6 | — | 0".6 cos (Arg. 8) |
| 1".8 | + | 1".8 cos 2 (Arg. 9) |
| 0".7 | + | 0".7 cos (Arg. 12) |
| 1".0 | + | 1".0 cos (Arg. 13) |
| 43".0 | + | 37".4 cos E + 0".4 cos 2 E |
| 30".0 | — | 1".0 cos V + 26".3 cos 2 V + 0".3 cos 3 V |
| 55' 40".0 | + | 187".0 cos A + 10".2 cos 2 A + 0".5 cos 3 A |

"The sum of the constants in this formula is 3420".5.

"The errors of the coefficients of equations 2 and 12 arise from the mistake respecting the formation of the argument of variation before explained, and those of the coefficients of equations 4 and 13 from the similar mistake respecting the argument of evection.

"Equation 6 is taken with a wrong sign, and in the variation equation 3 V appears to be wrongly substituted for 4 V, though I find that the corresponding term, when reduced to Burckhardt's form, has a smaller coefficient.

"In consequence of the way in which most of these errors originate, their amount will be generally greatest in March and September, and least about the beginning of January and July, when the sun's mean and true places coincide.

"The total error of Burckhardt's tables may amount to nearly 6", independently of the change in the value of the constant.

"Looking at the accuracy of modern observations, it is easy to imagine to what an extent the value of comparisons between observed and tabular places may be diminished by their being liable to an error of this kind.

"In determining differences of longitude by means of occultations, it is plain that the results may be considerably affected by such an error in the parallax. It has often been remarked, that differences of longitude obtained by means of different occultations are not so consistent with each other as might be expected from the precise character of the observation, and I have no doubt that a great part of the discrepancy is to be attributed to the use of an erroneous parallax.

"Mr. Maclear's observations at the Cape, combined with European observations, would doubtless furnish most valuable materials for a new determination of the constant of parallax, care being of course taken to employ correct tables in the reductions; and such a work would be a useful contribution to astronomy.

"In order to facilitate these and similar objects, Mr. Stratford has calculated the parallaxes from my tables for each Greenwich mean noon in the years 1840–1855, and has thus obtained the corrections to be applied to the corresponding quantities given in the *Nautical Almanac*.

"These corrections are embodied in tables which are appended to the present paper. Subsequently to 1855, the moon's parallax given in the *Nautical Almanac* is calculated from my tables."

Having made these preliminary remarks, Mr. Adams proceeds to give his new tables of the moon's parallax. These are succeeded by the corrections to be applied to the calculated parallaxes in the *Nautical Almanac* for the years 1840–55, as above referred to. The following are the corrections for the year 1853 :—

| Day of Mth. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | ″ | ″ | ″ | ″ | ″ | ″ | ″ | ″ | ″ | ″ |
| 1 | −0·4 | −1·1 | +0·5 | −0·7 | −0·4 | −0·8 | −0·2 | +0·2 | −1·0 | −2·5 | −3·8 | −2·8 |
| 2 | 0·3 | 2·1 | −0·6 | 1·7 | 1·1 | 0·6 | 0·0 | 0·0 | 2·0 | 3·6 | 4·9 | 3·2 |
| 3 | 0·4 | 2·9 | 1·7 | 2·5 | 1·5 | 0·4 | +0·1 | −0·4 | 3·2 | 5·0 | 5·5 | 3·4 |
| 4 | 0·8 | 3·8 | 3·0 | 3·1 | 1·8 | −0·2 | 0·3 | 0·9 | 4·4 | 5·9 | 5·6 | 3·5 |
| 5 | 1·3 | 4·4 | 4·0 | 3·4 | 1·7 | +0·3 | 0·5 | 1·5 | 5·0 | 6·4 | 5·5 | 3·2 |
| 6 | 1·8 | 4·5 | 4·7 | 3·3 | 1·3 | 0·5 | 0·5 | 2·3 | 5·4 | 6·3 | 4·7 | 2·8 |
| 7 | 2·3 | 4·4 | 4·6 | 2·9 | 0·8 | 0·8 | +0·1 | 2·8 | 5·1 | 5·8 | 4·3 | 2·3 |
| 8 | 2·8 | 3·9 | 4·3 | 2·4 | −0·4 | 0·9 | −0·2 | 2·9 | 4·4 | 5·1 | 3·5 | 1·7 |
| 9 | 3·0 | 3·3 | 3·7 | 1·9 | 0·0 | 0·7 | 0·5 | 2·7 | 3·3 | 4·0 | 2·3 | 1·0 |
| 10 | 3·1 | 2·7 | 3·0 | 1·2 | +0·2 | 0·6 | 0·6 | 2·3 | 2·5 | 3·1 | 1·2 | 0·3 |
| 11 | 3·0 | 2·1 | 2·4 | 0·9 | 0·4 | +0·4 | 0·9 | 1·6 | 1·6 | 2·0 | −0·5 | −0·2 |
| 12 | 2·8 | 1·8 | 1·9 | 0·7 | +0·2 | −0·2 | 0·9 | 1·0 | −0·8 | −0·7 | +0·2 | +0·2 |
| 13 | 2·5 | 1·3 | 1·4 | 0·5 | −0·1 | 0·8 | 1·0 | 0·8 | +0·1 | +0·2 | 0·9 | 0·5 |
| 14 | 2·2 | 1·0 | 1·0 | 0·7 | 0·6 | 1·6 | 1·0 | 0·4 | 0·7 | 1·3 | 1·3 | 0·6 |
| 15 | 1·8 | 0·9 | 0·8 | 1·0 | 1·5 | 2·4 | 1·2 | 0·3 | 1·4 | 2·0 | 1·3 | 0·5 |
| 16 | 1·5 | 1·0 | 0·7 | 1·7 | 2·5 | 3·0 | 1·5 | −0·2 | 1·8 | 2·4 | 1·1 | +0·1 |
| 17 | 1·5 | 1·0 | 1·0 | 2·6 | 3·4 | 3·2 | 1·6 | +0·1 | 1·9 | 2·3 | +0·5 | −0·2 |
| 18 | 1·4 | 1·1 | 1·4 | 3·3 | 3·9 | 3·2 | 1·7 | +0·1 | 1·7 | 1·7 | 0·0 | 0·6 |
| 19 | 1·3 | 0·8 | 1·6 | 3·4 | 4·2 | 3·0 | 1·6 | 0·0 | 1·2 | 1·2 | −0·3 | 1·2 |
| 20 | 1·0 | −0·4 | 1·8 | 3·3 | 3·7 | 2·8 | 1·8 | −0·5 | 0·4 | 0·6 | 0·4 | 1·6 |
| 21 | −0·6 | +0·6 | 1·7 | 2·5 | 2·9 | 2·7 | 2·1 | 0·8 | 0·1 | 0·3 | 0·3 | 1·9 |
| 22 | +0·1 | 1·5 | 1·3 | 1·2 | 2·1 | 2·7 | 2·3 | 1·0 | 0·0 | 0·5 | 0·3 | 1·9 |
| 23 | 0·8 | 2·1 | −0·1 | −0·1 | 1·4 | 2·8 | 2·6 | 1·2 | 0·2 | 0·6 | 0·2 | 1·9 |
| 24 | 1·4 | 2·6 | +1·0 | +0·7 | 1·2 | 2·8 | 2·4 | 1·0 | 0·7 | 1·0 | 0·1 | 1·9 |
| 25 | 1·9 | 2·7 | 1·9 | 1·2 | 1·4 | 2·5 | 2·2 | 0·7 | 1·1 | 1·2 | 0·3 | 2·1 |
| 26 | 1·9 | 2·5 | 2·5 | 1·2 | 1·1 | 2·0 | 1·7 | −0·1 | 1·2 | 1·2 | 0·4 | 2·1 |
| 27 | 1·6 | 2·0 | 2·7 | 1·0 | 0·8 | 1·6 | 1·1 | +0·4 | 1·1 | 0·9 | 1·0 | 2·1 |
| 28 | 1·2 | +1·5 | 2·5 | 0·8 | 0·4 | 1·1 | 0·6 | 0·6 | +0·9 | +0·3 | 1·4 | 1·9 |
| 29 | 0·6 | ... | 2·1 | 0·6 | 0·4 | 0·8 | −0·2 | 0·7 | 0·0 | −0·8 | 1·7 | 1·9 |
| 30 | +0·1 | ... | 1·3 | +0·1 | 0·5 | −0·6 | +0·3 | +0·5 | −1·2 | 1·7 | −2·2 | 1·8 |
| 31 | −0·5 | ... | +0·4 | ... | −0·7 | ... | +0·2 | −0·2 | ... | −2·8 | ... | −1·8 |

*Observations of two of the Satellites of Saturn, and of the Exterior Diameter of the Exterior Ring, made at Valetta.* By Mr. Lassell.

*Observations of Hyperion.*

| 1852. | G.M.T. h | m | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nov. 1 | 10 | 50 | precedes | Saturn's centre | | 225·0 | South of | Saturn's centre | | 52·9 |
| 2 | 10 | 54 | — | — | — | 190·0 | — | — | — | 67·8 |
| 3 | 11 | 18 | — | — | — | 134·8 | — | — | — | 85·3 |
| 4 | 12 | 52 | — | — | — | 81·9 | — | — | — | 92·0 |
| 5 | 10 | 31 | — | — | — | 19·6 | — | — | — | 97·7 |
| 6 | 11 | 17 | follows | — | — | 46·3 | — | — | — | 92·2 |
| 10 | 11 | 32 | — | — | — | 248·9 | — | — | — | 32·7 |
| 11 | 11 | 9 | — | — | — | 258·7 | — | — | — | 8·5 |
| 12 | 10 | 54 | — | — | — | 250·4 | North | — | — | 18·2 |
| 13 | 10 | 11 | — | — | — | 224·4 | — | — | — | 38·2 |
| 15 | 11 | 9 | — | — | — | 101·8 | — | — | — | 71·6 |
| 16 | 10 | 11 | — | — | — | 23·9 | — | — | — | 75·3 |
| 18 | 10 | 16 | precedes | — | — | 132·0 | — | — | — | 55·4 |
| 19 | 10 | 17 | — | — | — | 196·2 | — | — | — | 37·0 |
| 20 | 10 | 21 | — | — | — | 230·7 | — | — | — | 13·4 |
| 27 | 10 | 18 | follows | — | — | 32·6 | South | — | — | 89·8 |
| 29 | 10 | 1 | — | — | — | 154·6 | — | — | — | 75·3 |
| Dec. 2 | 8 | 49 | — | — | — | 252·6 | — | — | — | 18·0 |
| 3 | 9 | 51 | — | — | — | 256·7 | North | — | — | 8·0 |
| 9 | 11 | 15 | precedes | — | — | 111·6 | — | — | — | 58·0 |
| 13 | 10 | 12 | — | — | — | 225·8 | South | — | — | 31·8 |
| 15 | 9 | 29 | — | — | — | 165·7 | — | — | — | 67·3 |
| 20 | 8 | 26 | follows | — | — | 127·5 | — | — | — | 74·7 |
| 27 | 8 | 0 | — | — | — | 150·5 | North | — | — | 59·5 |
| 1853. Jan. 7 | 8 | 22 | precedes | — | — | 75·2 | South | — | — | 80·5 |
| 8 | 8 | 18 | — | — | — | 16·5 | — | — | — | 87·2 |
| 12 | 7 | 11 | follows | — | — | 194·3 | — | — | — | 53·8 |
| 14 | 6 | 39 | — | — | — | 242·7 | — | — | — | 15·4 |
| 15 | 5 | 43 | — | — | — | 242·1 | North | — | — | 13·3 |
| 17 | 5 | 57 | — | — | — | 169·2 | — | — | — | 50·1 |

Period deduced from five observations in 1850, compared with the above, 21·297 days.

A rather large ellipticity of orbit is shown by the above observations.

*Observations of Japetus.*

| 1852. | G.M.T. h | m | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 30 | 11 | 18 | precedes | Saturn's centre | | 293 | South of | Saturn's centre | | 206 |
| Nov. 1 | 10 | 50 | — | — | — | 195 | — | — | — | 195 |
| 3 | 10 | 54 | — | — | — | 119 | — | — | — | 195 |
| Nov. 5 | 10 | 31 | — | — | — | 19·6 | — | — | — | 169·8 |

| 1852. | G.M.T. h m | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nov. 6 | 11 30 | follows Saturn's centre | | | 46·3 | South of Saturn's centre | | | 159·6 |
| 10 | 11 32 | — | — | — | 217·6 | — | — | — | 106·0 |
| 11 | 11 9 | — | — | — | 261·5 | — | — | — | 89·5 |
| 13 | 10 11 | — | — | — | 343·9 | — | — | — | 59·1 |
| 15 | 11 30 | — | — | — | 409·6 | — | — | — | 25·4 |
| 16 | 10 31 | — | — | — | 447·4 | — | — | — | 7·6 |
| 18 | 10 25 | — | — | — | 507·6 | North | — | — | 26·7 |
| 19 | 10 27 | — | — | — | 517·9 | — | — | — | 46·4 |
| 20 | 10 36 | — | — | — | 551·2 | — | — | — | 68·3 |
| 27 | 10 33 | — | — | — | 589·3 | — | — | — | 163·2 |
| 29 | 10 39 | — | — | — | 568·9 | — | — | — | 186·5 |
| Dec. 3 | 10 6 | — | — | — | 485·8 | — | — | — | 217·4 |
| 13 | 10 18 | — | — | — | 113·8 | — | — | — | 195·4 |
| 15 | 9 29 | — | — | — | 28·8 | — | — | — | 175·7 |
| 27 | 8 30 | precedes | — | — | 431·7 | — | — | — | 6·5 |

*Measures of the Exterior Diameter of the Exterior Ring of Saturn and of the Polar and Equatoreal Diameters of his Disk.*

Diameter of Ring.

| 1852. | | No. | Power. | Reduced to Mean Dist. |
|---|---|---|---|---|
| Nov. 18 | 47·4 | 6 | 614 | 40·694 |
| 19 | 47·14 | 4 | ... | 40·490 |
| 29 | 47·59 | 7 | ... | 41·152 |
| Dec. 3 | 46·70 | 8 | ... | 40·529 |
| 20 | 46·32 | 5 | 614 | 41·046 |
| 24 | 45·66 | 6 | 760 | 40·580 |
| 27 | 45·55 | 7 | 614 | 40·794 |
| | | Mean = | | 40·881 |

Equatoreal Diameter.

| 1852. | | No. | Power. | Reduced to Mean Dist. |
|---|---|---|---|---|
| Nov. 19 | 20·96 | 3 | ... | 17·990 |
| 29 | 20·94 | 8 | ... | 18·107 |
| Dec. 3 | 19·03 | 6 | ... | 16·515 |
| 20 | 20·01 | 6 | ... | 17·732 |
| 22 | 19·29 | 10 | 760 | 17·143 |
| 24 | 19·53 | 7 | 760 | 17·409 |
| 27 | 19·29 | 2 | 614 | 17·276 |
| | | | Mean = | 17·453 |

Polar Diameter.

| 1852. | | No. | Power. |
|---|---|---|---|
| Nov. 29 | 19·14 | 10 | ... |
| Dec. 3 | 17·86 | 5 | ... |
| 20 | 17·67 | 5 | ... |
| 22 | 18·45 | 9 | 760 |
| 24 | 17·90 | 6 | 760 |

" The measures of the 3d December were taken under the especial determination *not to be in excess*, and probably I should otherwise have taken them somewhat larger. In several instances I have omitted to record the power, but I presume it would be 760, which I most frequently use when the air is in an average state. Comparing the mean of the five measures of polar diameter with the mean of those taken of the equatoreal diameter on the same days, $e = 0{\cdot}078764$, or $\frac{1}{12{\cdot}697}$, *i.e.* the apparent ellipticity, without applying the correction for the present inclination of the axis.

" The measures of the equatoreal diameter and major axis of ring differ considerably from those obtained by Professor Struve at Dorpat. With respect to the ellipticity, I would remark that, without a *perfect* driving motion, it is impossible to measure both diameters of the disk under equal circumstances.

The polar is perfectly easy, while the equatoreal, from being nearly in the direction of motion, is difficult. My driving motion being here somewhat temporarily fixed up is less steady than at home.

"*Valetta, February* 25, 1853."

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## *Extract of a Letter from Mr. Lassell.*

"*Valetta, 30th March*, 1853."

"Having concluded my observations here, I beg to hand a series of measurements in position and distance of a number of double stars which I have made, with a view of furnishing to astronomers the means of judging what personal or other equation may be applicable to my micrometrical measurements during my sojourn in this place. All the stars are well known and have been measured before, though of most of them I am ignorant of the results. Some of them are very unequal, and were chosen because they exhibited something like a type of a planet and faint satellite.

"Being all measured by the same observer, with the same telescope and micrometer, in the same place, and nearly at the same epoch, these measures will, I presume, furnish a good standard of comparison of my results with those of other observers.

"They were made, I believe, with neither more nor less care than those of my published observations, except that I paid less attention to accuracy in the *positions* of these stars than in the distances.

"*Measures of Stars made at Valetta for Verification of Measures of Satellites, &c.*

| Date. 1852. | Star. | Position. | No. of Measures. | Greatest Diff. of Individual Measures. | Magnifying Power. | Distance. | No. of Measures. | Greatest Diff. | Magnifying Power. |
|---|---|---|---|---|---|---|---|---|---|
| Dec. 21 | $\gamma$ Arietis | ... | ... | ... | ... | 8·84 | 7 | 0·67 | 614 |
| | $\gamma$ Arietis | ... | ... | ... | ... | 8·67 | 7 | 0·63 | 760 |
| | $\zeta$ Orionis | ... | ... | ... | ... | 56·84 | 8 | 0·84 | 760 |
| 28 | Rigel | ... | ... | ... | ... | 9·28 | 6 | 0·52 | 760 |
| 1853. | | ° ′ | | ° ′ | | | | | |
| Jan. 8 | $\gamma$ Androm. *b, c* | 107 51 | 8 | 2 28 | 1027 | | | | |
| | *a, b* | 61 15 | 3 | 0 28 | 1027 | 10·21 | 3 | 0·50 | 1027 |
| 17 | $\gamma$ Androm. *b, c* | 111 35 | 12 | 3 14 | 1027 | | | | |
| | *a, b* | 62 59 | 4 | 0 51 | 1027 | 11·27 | 5 | 0·87 | 760 |
| | Approximate R.A. h m / P.D. ° ′ | | | | | | | | |
| Mar. 12 | 9 20 / 81 7 | 82 0 | 3 | 0 39 | 614 | 25·60 | 8 | 2·30 | 614 |
| 14 | 9 20 / 81 7 | 81 21 | 9 | 1 1 | 614 | 25·82 | 9 | 1·00 | 614 |
| | *10 24 / 67 7 | 154 44 | 4 | 0 58 | 760 | 14·93 | 9 | 0·71 | 760 |
| | †11 27 / 72 19 | 211 13 | 4 | 0 51 | 760 | 3·34 | 8 | 0·35 | 760 |
| 15 | 8 31 / 69 46 | 54 36 | 6 | 1 50 | 760 | 20·29 | 8 | 0·67 | 760 |
| 17 | ‡8 36 / 71 16 | 121 7 | 6 | 1 11 | 760 | 45·82 | 8 | 1·25 | 760 |
| | §9 49 / 69 30 | 83 36 | 5 | 0 58 | 760 | 31·83 | 10 | 0·73 | 760 |

* Σ 1442, vi, 7.8
† Σ 1552, iii, 6.7
‡ δ Cancri
§ Σ 1339, viii, 7.8

*Discovery of a New Planet.* By M. Chacornac.

(*Extract of a Letter from M. Valz to Mr. Hind, dated April* 9, 1853.)

"I have the honour to announce to you the discovery of a new planet by M. Chacornac, on the 6th of April at $15^h$, upon our ecliptic chart for hour xiv. It is of the 9th magnitude, and appears of a bluish tint. I have proposed to call it *Phocea*, which recalls the origin of Marseilles, and to designate it by the symbol 24 enclosed in a circle. At $15^h 40^m$ M.T. it followed 27363 or 27366 of Lalande (which is merely the same star, not double), by $4^m 11^s.9$ of time, and was more to the north by $11' 2''$. In one hour its retrograde motion in right ascension was only $1^s$, and it had just passed the ascending node on the preceding day. On the following night, the sky being overcast, it was impossible to obtain a better determination of the direction of motion. On the 8th of April, at $11^h 58^m$, it followed No. 16 of zone 205 of Argelander, by $1^m 57^s$ of time, and was more to the north by $4' 22''$. It thus described about 30′ in 44 hours, under an inclination of 55° to the ecliptic, indicating thereby a very inclined orbit. I was induced by this circumstance to calculate the inclination upon the hypothesis of the circle, and found it to be 28° 7′; I also found the longitude of the ascending node to be 214° 48′. On the 5th of April, at $11^h$, the planet would have passed through the node at a distance of 2·4 from the sun; but this can only be regarded as a rough approximation. On the 8th of April, at $13^h$, the planet completely occulted a star of the eleventh magnitude, which may serve to procure a very accurate determination of its position.

"I herewith send you the elements which I have obtained for the last comet, which would appear to be the same as that of 1664, but very much enfeebled, if one may judge from the phenomena accompanying their respective apparitions."

Pass. Per. Feb. 24·067, 1853, M.T.

| | |
|---|---|
| Dist. Per. | 1·0761 |
| Long. Per. | 154° 49′ |
| Long. Asc. Node | 61 33 |
| Incl. | 18 32 |

Motion retrograde.

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*Discovery of a New Planet.* By Prof. De Gasparis.

(*Extract of a Letter from Professor De Gasparis to Mr. Hind, dated Naples, April* 10, 1853.)

"It is probable that you have already discovered the new planet, very near the ecliptic, which I discovered on the 5th of

April at Naples. I owe this discovery to the disappearance of a small star of the eleventh magnitude, which I had observed on the 5th of April, 1851. Fixing my attention upon the surrounding region, I took note of a small object (under the twelfth magnitude), the proper motion of which I recognised on the following evening.

" Here are the positions of the new planet :—

| 1853. | Naples M.T. h m s | R.A. h m s | Decl. ° ′ ″ |
|---|---|---|---|
| April 6 | 8 55 34 | 11 4 17·75 | +6 48 24 |
| 7 | 9 16 48 | 3 50·15 | 50 42 |
| 8 | 8 55 54 | 25·48 | 52 49 |
| 9 | 9 19 3 | 11 3 2·01 | +6 55 0 " |

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*Discovery of a New Comet.* By M. Schweizer of Moscow.

A comet was discovered at Moscow by M. Schweizer, on the 4th of April, 1853. It is a small, round, telescopic comet, without any tail. M. Schweizer estimates its diameter to be about 3′; he adds that he perceived from time to time indications of a nucleus. The following are its observed positions, as assigned by him :—

| 1853. | Moscow M.T. h m | Comet's R.A. h m s | Comet's Decl. ° ′ |
|---|---|---|---|
| April 4 | 15 0 | 20 3 20 | +13 4 |
| 5 | 14 0 | 20 4 25 | +13 1 |

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*Note from Mr. De La Rue.*

On referring to my notes relating to *Saturn*, I find that my measures of his disk were made on Nov. 19, 1852. On reducing the observations carefully, I have discovered an error which somewhat alters the mean values communicated to Mr. Dawes, and hence the ellipticity deduced therefrom. The following are the corrected numbers :—

| Polar Diameter. | Equatoreal Diameter. |
|---|---|
| ″ | ″ |
| 18·68 | 20·58 |
| 18·51 | 19·89 |
| 18·68 | 20·58 |
| 18·85 | |
| 18·68 | 20·35 |

the ellipticity is, therefore, $\frac{20{\cdot}35 - 18{\cdot}68}{20{\cdot}35} = 0{\cdot}082064 = \frac{1}{12{\cdot}1856}$

*April* 2, 1853.

*Extract of a Letter from the Rev. T. W. Webb to Capt. W. H. Smyth, R.N.*

"During the month of April 1852, while I was examining with my $5\frac{1}{2}$-feet achromatic the colour of the star $\beta$ in this constellation (*Coronæ*), and comparing it with the observation in your most valuable Bedford Catalogue, the remark which you have there made, that this star, though destitute of any Arabic name, is unquestionably the brightest in that asterism, induced me to compare it pretty attentively with its neighbours. I could not, however, at that time, estimate the star in question as the 'lucida'—on the contrary, their order of brightness, to the naked eye, as well as through a common concave eye-glass correcting my near sight, appeared to be evidently $\gamma, \delta, \beta, \alpha$. This was on April 13, 1852.

"A subsequent examination, on the night of April 19, in which, however, the concave eye-glass was not employed, confirmed this estimate. I have not as yet repeated the observation during the present season, but shall be interested in finding whether these stars still preserve the same comparative brightness to my eye, and still more in knowing whether you will agree with me; in which case, perhaps, a decrease of light in the star $\beta$, or less probably, an increase in the stars $\gamma$ and $\delta$, may be supposed to have taken place since the date of your observation in 1831.

"While I am on this subject I may, perhaps, mention, that I have found estimates of relative brightness between stars in the same telescope field, where there is no very obvious disparity, facilitated, or at any rate confirmed, by throwing the instrument a little out of focus; since the comparison between disks of sensible magnitude is rather more easy than between mere points: at any rate, there may be some advantage in its being presented to the eye under a fresh aspect. This method, however, appears still more useful in its application to the determination of the absolute brightness of minute bodies presenting visible, but unequal, disks, such as the satellites of *Jupiter*, where differences in apparent magnitude may confuse the accurate perception of intrinsic splendour. Thus, too, the absolute quantity of light emitted by a small planetary disk, or minute nebula, may be compared with that of the surrounding stars, if any suitable for the purpose are comprised in the same field.

"*April* 6, 1853."

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There was exhibited at the Meeting a modification of the model of a mounting for a large reflecting telescope, which had been proposed by the Astronomer Royal at the previous meeting, and of which a brief description was given in the last number of the *Monthly Notices*. In this altered form of the mounting, the polar bridle, instead of extending to the centre of the opening of the telescope, is attached to the back of the tube, by which means the

quantity of framework at the mouth of the tube is considerably diminished. The end contemplated in making this alteration was to obviate any objections which might be urged against the contrivance on the ground of the loss of light, or the injurious effects of diffraction, occasioned by the apparatus of bars at the mouth of the tube: Mr. Airy himself, however, appeared to prefer the original form of mounting to this new modification of it.

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## *On a Mounting for a large Reflecting Telescope.*

By Mr. W. Simms, jun.

The Astronomer Royal having at the last meeting called the attention of the Society to a model of a form of mounting for a large reflecting telescope, and at the same time expressed a desire that something better might be devised, I venture to submit to the Society a plan for a similar purpose, which I believe to exhibit some improvements.

In the accompanying model, the turn-table or altitude and azimuth motion is similar to that employed by the Astronomer Royal; the azimuth motion being effected by the table turning upon a strong vertical spindle resting on a conical socket at the lower end; and the altitude motion by a short transverse axis on one side of the telescope. Upon the same side a semicircle is mounted, turning upon two pivots in the direction of its diameter, the centre intersecting the line of the transverse axis; this is the declination arc. A polar axis with the hour-circle at its upper end is carried by a polar support in the usual way, its lower end being the centre of the declination arc which turns there upon an axis: now if the declination arc is clamped to the polar axis, the motion of the instrument will be entirely governed by the clock-work acting upon the hour-circle, precisely as in an ordinary equatoreal instrument, and a considerable range of equatoreal motion obtained, extending to eight or nine hours on each side of the meridian, the motion being as much under control near the zenith as in the lower altitudes, which is one of the improvements intended to be pointed out.

Another arrangement shown in the model is that of the eye-piece, which is fixed to the side of the telescope, so that the observer will not be required to change his position, however great a change may take place in the position of the telescope. A prolongation of the longitudinal axis of the declination arc is connected by means of bevel wheel-work with the eye-tube which is made to rotate, so that the position of a wire in the field would correspond with the equatoreal motion of a celestial object, as in the case of the eye-piece devised by the Astronomer Royal, which is made to rotate through part of the circumference of the mouth of the telescope.

*On the Mathematical Theory and Practical Defects of Clock Escapements, with a Description of a new Escapement, &c.* By James M'Kenzie Bloxam, Esq.

In this communication the author gives a very complete theory of the dead beat and the remontoire escapements, and shows that in some cases the remontoire is preferable. He also describes a remontoire gravity escapement, which appears to possess some peculiar advantages.

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*On the Classification of Comets and the Distribution of their Orbits in Space.* By Dr. Lardner.

The activity and zeal of observers and computers have of late years supplied vast additions to the knowledge of cometary astronomy. The elements of the orbits through which these bodies have moved through the system have been especially multiplied, and it might be naturally expected that if their orbits like those of the planets be regulated by any particular law in relation to their positions in space, either with reference to each other or with reference to any invariable plane passing through the centre of the sun, such law would be discoverable. It cannot fail, therefore, to be both interesting and useful to review and compare the numerous data thus supplied, with the especial view to the discovery of a law governing the position of the cometary orbits in space, if any such law exist; and if no such law exist, to demonstrate the remarkable fact that comets move in all conceivable directions, and in all conceivable planes, without any greater prevalence in any one direction or in any one plane than in any other.

The catalogues of Pingré and his contemporaries have been of late considerably enlarged by German astronomers, and a very complete one was published within the last few years by Dr. Mädler, in his elementary work on astronomy. This, however, has been lately continued to a much more recent date, and enlarged by the interpolation of several ancient comets, whose elements have been recovered from various traditions and historical records by the zeal and activity of Mr. Hind, to whom science is so largely indebted for his discoveries in this and other branches of practical astronomy.

Taking this enlarged catalogue of Mr. Hind as the most ample repertory extant of cometary data, we find that we are in possession of the elements of the motions of 207 comets. It is true that those which appeared before the middle of the seventeenth century can only be regarded as approximations, some of which may vary from the truth within considerably wide limits, and a few of the comets observed since that date have appeared for such periods, and under such disadvantageous conditions for observation as to supply rather imperfect data; still, on the whole, it may be considered that we have before us the elements more or less exact of the orbits

of 207 comets, whereon to base inductive reasoning directed to the discovery of the laws which govern their position, if any such exist.

Of these 207 comets, it appears that 40 move in ellipses, 7 in hyberbolas, and 160 in parabolas.

The 40 comets to which elliptic orbits have been assigned may be conveniently classified in three groups, as follows :—

1st group — 13 comets, whose aphelia are included within *Saturn's* orbit.

2d group — 6 comets, whose mean distances are nearly equal to that of *Uranus*.

3d group — 21 comets, whose mean distances exceed in a greater or less proportion the extreme limits of the solar system.

*First group of elliptic comets.*—The 13 comets composing this group are as follows :—Encke, Biela, Faye, De Vico, Brorsen, D'Arrest, Clausen (1743), Burckhardt (1776), Lexell (1770), Blainpain (1819), Pons (1819), Pigott (1783), Peters (1846).

By reference to Mr. Hind's table, it will be perceived that these 13 comets retain in a striking manner many of the characteristics of the planetary motions; they are all, without a single exception, *direct;* their inclinations (with one single exception) are all included within the planetary limits, and even the exceptional comet does not much exceed the inclination of *Pallas;* the excentricities, though of an order of magnitude greatly exceeding even that of *Juno* (the most excentric of the planets), still are incomparably less than those of the other comets. While the aphelia of these orbits generally lie a little within or without the orbit of *Jupiter*, their perihelia are included between the orbits of *Mars* and *Mercury*, the only exception to this being Peters' comet, whose perihelion lies beyond the orbit of *Mars*, while the aphelion extends to the orbit of *Saturn*.

*Second group.*—Comets of Halley, Pons (1812), Olbers (1846), De Vico (1846), Brorsen (1847), Westphal (1852).

Of the 6 comets which compose this group, 5 have direct motion, that of Halley alone being retrograde. The orbits, however, in all other respects differ in a striking manner from those of the first group, and retain no other trace of resemblance to the planetary orbits. The excentricities are great compared with those of the first group, and of an order to efface all analogy whatever with the planetary ellipses. Their inclinations also range far beyond the planetary limits.

It would, therefore, appear, that this group holds an intermediate place between the first group and the more numerous classes which we are now about to notice.

*Third group.*—Comets of 1680, 1683, 1763, 1769, 1780, 1793, 1807, 1811 (A), 1811 (B), 1822, 1825, 1827, 1830, 1840 (A), 1840 (B), 1843, 1844, 1845, 1846 (A), 1846 (B), 1849.

Of the 21 comets composing this group, 11 are retrograde and 10 direct.

It appears, therefore, that the tendency to direct motion, which

prevails with a single exception in the first two groups, is entirely effaced in the last; no tendency, on the other hand, however, being discoverable towards the other direction, since the proportion of 11 to 10 in favour of retrograde motion must be regarded as casual.

*Fourth group.*—Comets of 1729, 1771, 1774, 1818, 1824, 1840, 1843.

Of the 7 hyperbolic comets composing this group, 6 are direct; but among their orbits there appears to be no other prevalent character.

*Fifth group.*—This group consist of 160 comets, whose orbits are sensibly parabolic.

The distribution of these bodies with relation to the direction of their motion is as follows:—

| | |
|---|---|
| Direct | 70 |
| Retrograde | 86 |
| Unascertained | 4 |
| | 160 |

This would indicate a slight tendency in favour of retrograde motion, but if we take into account the entire number of comets whose orbits are ascertained this tendency will then disappear, for we shall then have,

| | |
|---|---|
| Direct | 94 |
| Retrograde | 99 |
| Unascertained | 4 |
| | 207 |

This difference in favour of retrograde motion must be considered as casual, and, so far as the data now before us extend, it must be inferred that the comets taken generally, unlike the planets, show no prevailing tendency either to direct or retrograde motion, but that the elliptic comets of the smaller excentricities show a decided tendency to direct motion.

To determine whether the planes of the cometary orbits are characterised by any prevailing tendency towards a particular inclination, it will only be necessary to ascertain the number of orbits whose inclinations are included between certain definite limits.

It appears from a table which I have formed, exhibiting the proportion of comets in every 100, whose inclinations are included within every successive 10° of the quadrant, that the planes of the orbits of the comets have a decided tendency to crowd around an inclination of about 45°, or to take positions which would be those of tangent planes to a right cone, whose axis would be at right angles to the plane of the ecliptic, and whose semi-angle would be 45°.

That this tendency is too marked to be considered as casual, will be admitted when it is considered that the mean number of inclinations per cent due to each 10° would be 11, while the number of inclinations included between 40° and 50° is nearly 16, being nearly 50 per cent greater than the mean.

To determine, in like manner, whether the nodes and perihelia exhibit any preference for any particular longitude, I have constructed a table giving the number of nodes and the number of perihelia in every 100 included within every 30° of longitude, from 0° to 360°.

From this table it would appear that there is a tendency in the nodes to crowd into the third and seventh signs of the ecliptic. The mean number of nodes due to each sign being 8·33, the number of the third sign is very nearly 12, and the number in the seventh nearly 10; the former being nearly 50 per cent and the latter 20 per cent above the mean.

The perihelia, in the same manner, show a tendency to crowd into the third, fourth, and tenth signs, the numbers in the third and fourth being 12, and the number in the tenth nearly 13, each being about 50 per cent above the mean.

It is difficult to conceive, when the large number of comets upon which these calculations have been based, is considered, that these results, either as regards the perihelia or the nodes, can be casual.

The distribution of the points where the comets arrive at perihelion, with reference to their distances from the sun, supply another ground of classification.

This object may be effected by the formation of a table, exhibiting the number of comets in every 100 which have their perihelia between the surfaces of spheres distributed round the sun, with the radii of 20, 40, 60, &c. millions of miles.

It appears from such a table that only a small proportion of the perihelia lie outside the sphere, whose radius is 120 millions of miles. This circumstance must be ascribed to the fact, that comets moving in such orbits will mostly escape observation; but it may, perhaps, be assumed that, *cæteris paribus*, the comets, whose perihelia lie within a sphere through the earth's orbit, have nearly equal chances of being observed. If this be assumed, then it will follow that the numbers of such comets which have been observed are nearly proportioned to their total numbers; and, therefore, that the numbers within this limit in the preceding table do actually represent approximately the distribution of the points of perihelion round the sun.

If we compare, then, the number of perihelia situate between the equi-distant spheres indicated in the table above referred to, with the cubical spaces through which they are respectively distributed, we shall obtain an approximate estimate of the *density* of their distribution in relation to the distances from the sun. I have computed the following table with this view. In the second column I have given the number of comets per cent, whose perihelia are included between the equi-distant spheres: in the third column, the numbers express the cubical spaces between sphere and sphere, the volume of the sphere, whose radius is 20 millions of miles, being the cubical unit; and in the fourth column the numbers are the quotients of those in the second, divided by those in the third; and,

therefore, express the successive densities of the perihelia between sphere and sphere.

| | Numbers of Perihelia. | Cubical Space. | Density of Perihelia. |
|---|---|---|---|
| 0 — 20 | 8·65 | 1 | 8·65 |
| 20 40 | 11·70 | 7 | 1·67 |
| 40 60 | 20·30 | 19 | 1·06 |
| 60 80 | 17·20 | 37 | 0·47 |
| 80 100 | 20·80 | 61 | 0·34 |
| 100 120 | 8·65 | 91 | 0·095 |

It is evident, then, that the density of the perihelia increases rapidly in approaching the sun. If the numbers in the last column of the table be compared with the inverse powers of the distance, it will be found that this increase of density is more rapid than the inverse distance, but less so than the inverse distance squared.

Two planes being supposed to be drawn, each at an angle of 45° with the plane of the ecliptic, and so that the intersection of one of them with the plane of the ecliptic is directed to the 75° of longitude, and that of the other to the 200° of longitude, there is a tendency of the cometary orbits to crowd towards the directions of these planes, not certainly so decided as to establish a law, but too pronounced to be casual.

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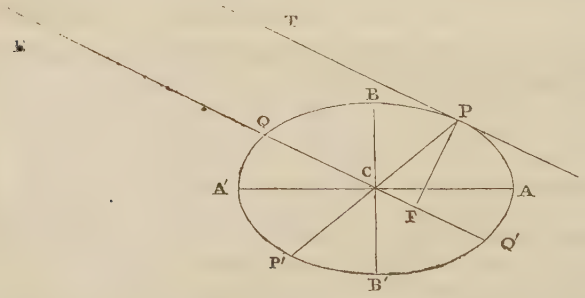
*Note on the Correction to be applied to the Apparent Ellipticity of a Planet, in consequence of the Elevation of the Earth above the Plane of the Planet's Equator.* By Mr. Grant.

As the subject of the ellipticity of the planets, more especially *Saturn*, appears to excite considerable interest at present among astronomers, it may be desirable to exhibit a convenient mode of computing the effect due to the elevation of the earth above the plane of the planet's equator.

Let A B A′ B′ represent an elliptical section of the planet formed




by a plane passing through the polar axis B B′ and the eye of an

observer at the surface of the earth. Let A A′ be the equatoreal diameter situate in this plane, and let C Q E represent the direction of the observer, with respect to C, the centre of the planet. It is manifest that the angle A′ C E will then represent the elevation of the earth above the plane of the planet's equator. Let P P′ represent the extremities of the apparent polar axis of the planet, and let the direction of the visual ray at P be indicated by P T, which will evidently be a tangent at that point to the elliptical section of the planet. Moreover, since the radius C P is small compared with the distance of the earth from the planet, P T may be supposed without sensible error to be parallel to E C, and, consequently, Q Q′ will be a conjugate diameter to P P′.

Draw P F perpendicular to Q Q′. The apparent semi-polar axis will obviously be measured by the angle which this line subtends at the place of the observer on the surface of the earth.

Let $\angle$ A′ C Q $= \phi$, P F $= p$.

By the well-known property of the ellipse, we have

$$PF = \frac{AC \times BC}{CQ}$$

$$\text{or} \qquad p = ab \cdot \frac{\sqrt{1 - e^2 \cos^2 \phi}}{a\sqrt{1 - e^2}}$$

$$\text{Hence} \qquad b = p \cdot \frac{\sqrt{1 - e^2}}{\sqrt{1 - e^2 \cos \phi}}$$

$e$ being the *eccentricity* of the spheroid.

This expression agrees with Bessel's remark (*Ast. Nach.* vol. xii. p. 169), wherein he states that the reduction of the projection of the spheroid upon its lesser axis may be effected by multiplying the apparent polar diameter by $\frac{\sqrt{1 - e^2}}{\sqrt{1 - e^2 \cos^2 \phi}}$.

It may, however, perhaps, be found convenient to present this result in the form of a *correction* to the apparent ellipticity of the planet, so as to deduce the true ellipticity from the apparent, and *vice versâ*, independently of a knowledge of the polar diameter.

$$\text{Now} \qquad p = \frac{b\sqrt{1 - e^2 \cos^2 \phi}}{\sqrt{1 - e^2}} = a\sqrt{1 - e^2 \cos^2 \phi}$$

$$\therefore \qquad \frac{p}{a} = \sqrt{1 - e^2}\sqrt{1 + \frac{e^2}{1 - e^2} \cdot \sin^2 \phi}$$

$$= \sqrt{1 - e^2} + \frac{1}{2} \cdot \frac{e^2}{\sqrt{1 - e^2}} \cdot \sin^2 \phi - \frac{1}{8} \cdot \frac{e^4}{(1 - e^2)^{\frac{3}{2}}} \cdot \sin^4 \phi + \&c.$$

$$\text{or} \qquad \frac{p}{a} = \frac{b}{a} + \delta,$$

putting $\delta = \frac{1}{2} \cdot \frac{e^2}{\sqrt{1-e^2}} \cdot \sin^2\phi - \frac{1}{8} \cdot \frac{e^4}{(1-e^2)^{\frac{3}{2}}} \sin^4\phi$ + &c.

Hence $$1 - \frac{b}{a} = 1 - \frac{p}{a} + \delta$$

or $$\epsilon = \epsilon' + \delta,$$

where $\epsilon$ denotes the *true* ellipticity of the planet, and $\epsilon'$ the *apparent* ellipticity.

It appears, then, that $\delta$ represents the correction to be applied to the apparent ellipticity of the planet, in order to determine the true ellipticity,

Since $$\frac{p}{a} = \frac{b}{a} + \delta$$

$$\therefore \quad b = p - a\,\delta$$

In this case then $a\,\delta$ denotes the correction of the polar semi-diameter.

When the question refers to the actual ellipticity of any planet, the first two terms of $\delta$ will be found quite sufficient for all practical purposes. We may, therefore, thus recapitulate the results,—

$$\epsilon' = 1 - \frac{p}{a} \tag{1}$$

$$\delta = \tfrac{1}{2} \cdot \frac{e^2}{\sqrt{1-e^2}} \cdot \sin^2\phi - \tfrac{1}{8} \cdot \frac{e^4}{(1-e^2)^{\frac{3}{2}}} \cdot \sin^4\phi \tag{2}$$

$$\epsilon = \epsilon' + \delta \tag{3}$$

$$b = p - a\,\delta \tag{4}$$

The last equation will be applicable in the case wherein it is required to deduce from a series of measures of the *apparent* polar diameter made in different parts of the planet's orbit, the corresponding values of the *true* polar diameter with the view of subjecting the results to direct comparison, after they have been reduced to the mean distance from the earth.

The numerical values of the coefficients of $\sin^2\phi$, $\sin^4\phi$, in the expression for $\delta$, may be readily determined in any particular case from any assigned value of the ellipticity. Thus, with respect to *Saturn*, if we assume with Bessel,

$$\epsilon = 0{\cdot}098{,}048$$

we have $$e = \sqrt{2\epsilon - \epsilon^2} = 0{\cdot}431845$$

therefore $$\delta = (9{\cdot}014{,}4440)\sin^2\phi - (7{\cdot}772{,}6766)\sin^4\phi$$

and, consequently,

$$\epsilon = \epsilon' + (9{\cdot}014{,}4440)\sin^2\phi - (7{\cdot}772{,}6766)\sin^4\phi$$

where the numbers within the parentheses represent the logarithms of the coefficients.

The correction will manifestly attain its maximum value when the earth has ascended to its greatest elevation above the equator of the planet. According to Bessel, the inclination of the plane of the ring (and consequently that of the equator of the planet) to the ecliptic, amounts to $28^\circ\ 10'\ 44''\cdot7 - 0''\cdot350\ (t - 1800)$. In consequence of the latitude of the planet, when it is at a distance of 90° from the node of the ring, the maximum elevation of the earth above the equator of the planet will generally be somewhat less than this quantity. Let us suppose the maximum elevation of the earth to be 27°, we have, then,

$$\delta = 0\cdot021{,}055$$

$$\epsilon' = \epsilon - \delta = 0\cdot098{,}048 - 0\cdot021{,}055$$

$$= 0\cdot076{,}993 = \frac{1}{12\cdot9882}$$

This is, therefore, the minimum apparent ellipticity which the planet can exhibit, supposing the true ellipticity to be 0·098048.

Next to determine the ellipticity indicated by Mr. De La Rue's measures. It appears from his note that they were made on November 19, 1852. Now, if we calculate the elevation of the earth above the equator of the planet for the same day, by means of Bessel's elements of the ring (*Ast. Nach.* vol. xii., p. 170), we find it to be 20° 32'·1. Hence, using the value of $e$ deducible from Bessel's measures, we obtain $\delta = 0\cdot012{,}631$, and repeating the process with the new value of $e$ deducible from this result, we obtain for the more accurate value of the correction,

$$\delta = 0\cdot012{,}177.$$

Again, the mean value of his measures of the apparent polar diameter was found by him to be 18''·68, and the mean value of the equatoreal diameter to be 20''·35.

Whence $$\epsilon' = 0\cdot082{,}064 = \frac{1}{12\cdot1856}$$

and $$\epsilon = \epsilon' + \delta = 0\cdot082{,}064 + 0\cdot012{,}177$$

$$= 0\cdot094{,}241 = \frac{1}{10\cdot611}$$

The corresponding value of the *apparent* ellipticity deducible from Bessel's measures, is,

$$\epsilon' = \epsilon - \delta = 0\cdot098{,}048 - 0\cdot012{,}631 = 0\cdot085{,}417.$$

The measures from which Mr. Lassell deduced the apparent ellipticity mentioned by him in his letter to Mr. De La Rue, inserted in the *Monthly Notices* for January, viz. $\frac{1}{12\cdot697} = 0\cdot078\ 764$,

appear to have been made about the same time.* Hence, assuming the same value of $\phi$, we obtain $\delta = 0{\cdot}011{,}734$, and therefore,

$$\epsilon = \epsilon' + \delta = 0{\cdot}078{,}764 + 0{\cdot}011{,}734$$
$$= 0{\cdot}090{,}498 = \frac{1}{11{\cdot}050}$$

The corresponding value of $\epsilon'$, deducible from Mr. Main's ellipticity, viz. $\frac{1}{9{\cdot}227}$, will be $0{\cdot}09434 = \frac{1}{10{\cdot}6}$; and the value for the same date, indicated by the ellipticity which Mr. Main has derived from the measures made by Bessel during the almost total disappearance of the ring, viz. $\frac{1}{9{\cdot}06}$, will be $0{\cdot}09608 = \frac{1}{10{\cdot}408}$.

As a wish has been expressed to have some standard of comparison in observations of this kind, the following table has been calculated for the latter part of the present year, from the values of the equatoreal and polar diameters of the planet corresponding to the mean distance from the sun (log = 0·979,6480), as deduced by Bessel from the totality of his measures, viz. 17″·053 and 15″·381 respectively. The second column in the table exhibits the elevation of the earth above the equator of the planet, which is, in the present instance, towards the *south* pole of the planet. The third and fourth columns contain the corresponding *apparent* equatoreal and polar diameters of the planet. The numbers in the fifth column give the correction to be applied to the true ellipticity in order to find the apparent ellipticity, the values of which are exhibited in the sixth and last column. The table commences with the 1st of September, when the planet will have become sufficiently favourable for observation.

| Date. 1853. | $\phi$ | $2a$ | $2b$ | $\delta$ | $\epsilon'$ |
|---|---|---|---|---|---|
| | ° ′ | ″ | ″ | | |
| Sept. 1 | 24 53·8 | 18·253 | 16·795 | 0·01814 | 0·07991 |
| 11 | 24 53·1 | 18·590 | 17·104 | 0·01812 | 0·07993 |
| 21 | 24 51·0 | 18·922 | 17·409 | 0·01807 | 0·07998 |
| Oct. 1 | 24 47·4 | 19·237 | 17·697 | 0·01799 | 0·08005 |
| 11 | 24 42·6 | 19·521 | 17·956 | 0·01788 | 0·08016 |
| 21 | 24 36·7 | 19·761 | 18·174 | 0·01775 | 0·08030 |
| 31 | 24 29·8 | 19·944 | 18·339 | 0·01760 | 0·08045 |
| Nov. 10 | 24 22·3 | 20·059 | 18·442 | 0·01743 | 0·08062 |
| 20 | 24 14·5 | 20·098 | 18·475 | 0·01726 | 0·08079 |
| 30 | 24 6·9 | 20·060 | 18·436 | 0·01710 | 0·08096 |
| Dec. 10 | 24 0·0 | 19·946 | 18·328 | 0·01694 | 0·08111 |
| 20 | 23 54·3 | 19·762 | 18·157 | 0·01682 | 0·08123 |
| 30 | 23 50·2 | 19·520 | 17·933 | 0·01673 | 0·08132 |

* Mr. Lassell's measures have been communicated to the Society since the above was written, and are inserted at page 183 of the present number of the *Monthly Notices*.

## *On Twinkling.* By M. Arago.*

M. Arago commences his inquiry by giving an exact definition of the term *scintillation*. It is, he remarks, from not adopting a similar practice that astronomers and other physical inquirers have hitherto failed to arrive at a satisfactory explanation of the phenomenon. He affirms, then, that, in so far as naked-eye observers of the heavens are concerned, scintillation or twinkling consists in very rapid fluctuations in the brightness of the stars. These changes are almost always accompanied by variations of colour and certain secondary effects, which are the immediate consequences of every increase or diminution of brightness; such as considerable alterations in the apparent magnitudes of the stars, and in the length of the diverging rays, which appear to issue in different directions from their centres.

It has been remarked from a very early age that the phenomenon of twinkling is accompanied by a *change of colour*. M. Arago states, upon the authority of M. Babinet, that the name of *Barakesch*, given by the Arabians to the star *Sirius*, signifies *the star of a thousand colours*. He also cites various passages from the works of Tycho Brahé, Kepler, and other modern inquirers, indicative of a similar change of colour attending the process of twinkling.

M. Arago asserts further, that *the twinkling of the planets* is a well-established fact. Thus observers generally, from Tycho Brahé downwards, have remarked that *Mercury* twinkles very strongly. Gassendi even maintains that it is on account of this circumstance that the appellative Στιλβων has been applied to the planet. *Venus* has also been observed to twinkle, and even *Mars* and *Jupiter*, though feebly. Tycho Brahé has remarked that *Saturn* never twinkles; but this opinion has been controverted by Scheiner and other observers, although it is generally admitted that the phenomenon is exceedingly difficult to be recognised in the case of this planet.

An impression has generally prevailed that the stars do not twinkle in telescopes. M. Arago, however, asserts that this opinion is erroneous. Even a few years after the invention of the telescope Simon Marius remarked that, by removing the eye-piece of the telescope, the images of the stars and planets appear enlarged, and exhibit rapid fluctuations of brightness and colour. In 1813, Nicholson showed that a similar phenomenon would be produced if the eye-piece of an achromatic telescope was pushed out of focus. The same inquirer also gave an account of another experiment, which tended to illustrate the rapid fluctuation of colour which the stars undergo during the process of twinkling. The telescope being adjusted to distinct vision, he applied to it a smart vibration, which caused the image of the star to be transformed into a curved line of light, returning into itself, and diversified by

* *Annuaire du Bureau des Longitudes*, 1852, pp. 365–504.

several colours. A similar phenomenon presented itself on the occasion of each successive vibration. He estimates that each colour occupied about a third of the whole length of the curve, and assuming that he applied ten vibrations to the telescope in the course of a second, he hence concluded that the light of *Sirius passes through thirty changes of colour in a second of time.*

It follows, as a necessary consequence of this experiment, that the stars in general shine only by a portion of their light, the effect of twinkling being to diminish their brightness. It is easy to conceive, therefore, that a star which is estimated to be of the seventh magnitude, because it is usually invisible to the naked eye, might become distinctly perceptible if the phenomenon of twinkling were to cease.

After giving a detailed account of the circumstances which accompany the twinkling of the celestial bodies, and of the modifications to which they are subject, M. Arago next proceeds to explain his views of the physical origin of the phenomenon. He maintains that the only satisfactory theory which can be advanced on the subject is that which connects the phenomenon with the principle of the interference of light. He illustrates the latter principle by the well-known experiment, in which two rays of light emanating in different directions from a luminous point, are made to converge again by being reflected from the surfaces of two mirrors, and to combine together, or to destroy each other, according to the conditions of the experiment. If the light from which the rays issue be homogeneous, and if the routes severally traversed by them be made to *differ in length* by gradually displacing one of the mirrors, the point where they meet after reflexion will, in some positions of the movable mirror, exhibit a very vivid light, while in other intermediate positions it will appear *quite black*. The positions of the movable mirror, corresponding to which the two rays thus alternately conspire together, or destroy each other, will vary with the colour of the spectrum employed in the experiment. It results from this important fact, that when rays of white light emanate from the luminous point, they will exhibit at their point of concourse after reflexion a succession of prismatic colours, depending in each case on the position of the movable mirror.

It is found that similar effects may be produced if, instead of causing the routes of the two rays to differ in length, the *refrangibility* of the media through which they pass be subjected to a similar variation.

It is upon these two facts that M. Arago has established his theory of scintillation.

In the case of telescopic observations, he supposes that the rays of light which enter the telescope at opposite extremities of a diameter of the object-glass may have traversed strata of the upper regions of the atmosphere, which, either from variations of density or temperature, or from hygrometric causes, may possess different refractive powers. It might happen from this cause, that the red rays at the one extremity of the diameter might totally destroy

those at the opposite extremity, and that the focus might pass from the normal colour of white to that of *green*, the complimentary colour of red. In the next instant the green might be totally destroyed, and the colour at the focus would, consequently, be red; and similar effects might manifestly be produced each successive instant, by the destruction now of one colour and now of another colour of the spectrum.

Generally, the rays will only *partially* destroy each other by their interference; in which case the light will still be coloured at the focus, although less intensely than if the destruction had been complete.

M. Arago had already established by experiment, that if even the twentieth part of a pencil of light were extinguished by the interference of any of the homogeneous rays, the light at the focus would appear *sensibly* coloured. It would, therefore, be sufficient that the strata of the atmosphere should, by reason of their unequal refrangibility, affect intermittently, and in a suitable degree, the twentieth part of the rays which the surface of a lens embraces in order that the focal point should acquire in succession the different prismatic colours. "Now," says M. Arago, "if we take into consideration the great length of the route traversed by the light from the superior limits of the atmosphere to the object-glass of the telescope; if we reflect, moreover, on the small difference of refrangibility which suffices to occasion the passage of two rays from the state of accord to that of destruction, on the effect of winds, however moderate, bringing incessantly new atmospheric strata before the telescope, it cannot excite any surprise that in observing *Sirius*, a star sufficiently low in our latitudes, as many as thirty changes of colour in a second have been noted." Having thus explained, by the principle of the interference of light, the twinkling of the stars in telescopes, M. Arago finds no difficulty in applying the same explanation to observations with the naked eye.* He then proceeds to show how the twinkling of the planets may be accounted for by the same principle, and he concludes the exposition of his views on this interesting subject by suggesting three different modes of measuring the scintillation of a star. We shall confine ourselves to a brief notice of the first of these *scintillomètres*, as he terms them, which is unquestionably the most ingenious in its conception, and the most conclusive as regards the character of its results. It depends on an experiment, which is originally due to M. Arago himself, and which he first gave an account of in the year 1824.† If a diaphragm be placed before the object-glass of a telescope, so as to allow the light to pass through a circular aperture, and if a

* M. Arago has mainly explained the phenomenon of twinkling, whether as discernible in telescopes or as visible to the naked eye, by the unequal refrangibility of the media traversed by the rays of light which enter the object-glass of the telescope or the eye of the observer; but he has also endeavoured to show that some difference must exist in the *lengths* of the routes traversed by the rays, which would be capable in some degree of accounting for the phenomenon.

† *Annales de Chimie et de Physique*, tome xxvi. p. 431.

star be observed with the telescope when the eye-piece is in the position of distinct vision, the image of the star will resemble a vacillating disc of light surrounded by alternate dark and bright rings. If the eye-piece be now gradually pushed in, there is a second position, in which the luminous disk in the centre will be replaced by a *black hole* surrounded by alternate bright and dark rings. By continuing to push the eye-piece towards the focus a third position will be found, in which the image will resemble that observed in the first instance; and thus a constant recurrence will take place as the eye-piece is pushed forward, the image alternating between a *luminous centre* surrounded by *dark* and bright rings, and a *central dark hole* surrounded by *bright* and dark rings. Now, to determine the second position of the eye-piece, viz. that in which the image of the star exhibits a black hole in its centre, instead of observing the star directly, the eye-piece may be placed exactly midway between the first and third positions. If the telescope be now directed to a star which twinkles, the phenomenon will manifest itself in a succession of accidental reappearances of a luminous point in the dark hole, *and these reappearances will be more numerous as the twinkling is stronger.* At the request of M. Arago, a series of observations of this kind were made by MM. Goujon and C. Matthieu. The following selection will serve as an illustration of them :—

*Jan.* 14, 1851.

| Stars. | Height above the Horizon. | Number of Apparitions in Five Minutes. |
|---|---|---|
| Sirius | 20° | 40 |
| Rigel | 31° | 17 |
| Aldebaran | 57° | 13 |
| Capella | 81° | 8 |

*Jan.* 22, 1851.

| | | |
|---|---|---|
| Sirius | 24° | 28 |
| Procyon | 46° | 20 |
| $\alpha$ Orionis | 48° | 15 |
| Pollux | 69° | 12 |

M. Arago had concluded from theoretical considerations, that if the eye-piece were shifted from the second position to some position intermediate between the second and third, the apparitions of the luminous point would be more frequent than in the first instance. The results of actual observations afforded a complete confirmation of his conclusion.

Having fully expounded his own view of the origin of twinkling, M. Arago next examines the various theories advanced by preceding writers on the subject, and points out their inadequacy in every case to account for the phenomena.

M. Arago states that although he feels convinced that, in connecting the phenomenon of scintillation with the principle of interferences, he has viewed the subject in its proper aspect, still he is

far from being of opinion that nothing further remains to be done. "For example," says he, "no one of my acquaintance has connected in an entirely satisfactory manner, and even to their numerical values, the planetary disks which the stars acquire, and the rings which surround them, with the theory of interferences." He adds, that he had been informed that M. Schwerd, a geometer of Germany, had succeeded in this research; but he was told at the same time that, according to the calculations of M. Schwerd, which besides were applied exclusively to simple lenses not achromatic, the diameters of the planets when seen in a telescope with a reduced aperture ought to appear enlarged like the stars, a result entirely contradicted by observation.*

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*Exposé historique des Travaux exécutés jusqu'à la fin de l'année* 1851, *pour la Mesure de l'Arc du Méridien entre Fuglenæs,* 70° 40′, *et Ismüil,* 45° 20′. *Publié au Nom de l'Académie Impériale des Sciences de St. Pétersbourg, par W. Struve, Directeur de l'Observatoire Central de Russie. Suivi de Deux Rapports de M. G. Lindhagen, Astronome de l'Observatoire central sur l'Expédition de Finmarken, faites par Ordre du Gouvernement Norvégien en* 1850; *et sur les Opérations de Lapponie, exécutées en* 1851, *sous les Auspices de l'Académie Royale des Sciences de Stockholm.* 4to. pp. 44. St. Pétersbourg, 1852.

In this Report M. Struve gives a brief history of the operations connected with the measurement of the Russo-Scandinavian arc of the Meridian, which has now attained the colossal extent of 25° 20′. This great undertaking was first commenced in Russia in the year 1816, and was finally brought to a close in 1851, the labours of its execution having, consequently, embraced a period of thirty-seven years.

As has happened in some other similar instances, the measurement of this arc was not an independent project undertaken with a view to the advancement of physical science, but was suggested by the operations connected with the trigonometrical survey of a portion of the Russian empire. In 1816, M. Struve and General Tenner were charged, the one with the trigonometrical survey of Livonia and the other with that of Lithuania; and it occurred to both geometers to profit by their labours in measuring an arc of the meridian in their respective provinces.

* In the *Cambridge Philosophical Transactions*, vol. v. p. 283 *et seq.*, Mr. Airy, proceeding upon the principles of the undulatory theory of light, has investigated the diffraction produced by an object-glass having a reduced aperture of a circular form, and has calculated the numerical values of the diameters of the spurious disks of the stars and of the alternate dark and bright rings surrounding them. The results were found to present a satisfactory agreement with Fraunhofer's measures.—Editor.

It has been established by numerous experiments made with the pendulum in different parts of the world, that the parallels on the surface of the earth are nearly circles; or in other words, that the earth, supposing its surface reduced to the level of the ocean, may be regarded as a solid of revolution. From this circumstance it follows, that we may investigate the dimensions and figure of the earth by combining together the partial arcs measured under different longitudes. The solution of the problem would not, therefore, present any serious difficulty, were it not that, independently of the unavoidable small errors of observation, there exists a disturbing influence, which generally affects the comparison of two arcs of the meridian measured under very different latitudes. This consists in a deviation of the plumb-line, occasioned either by the inequalities of the surface of the earth *above* the level of the ocean, or by irregularities in the densities of the strata *beneath* the same level, which tends in a greater or less degree to vitiate the result of every measure of an arc of the meridian. According to the researches of the illustrious Bessel, the probable error of a determination of latitude due to this cause amounts to $1''{\cdot}8$. Hence it is manifest, that the accuracy of the final results in any case will be enhanced by selecting for the field of operations a region subject as little as possible to local disturbance, and by giving a considerable extension to the arc measured.

The region through which the Russian arc extends appears to offer peculiar advantages for geodesical operations, in so far as the effects due to inequalities on the surface of the earth are concerned. Throughout the whole of this region, extending from the Danube to Lapland, and comprising an arc of the meridian of $20^\circ$, there does not exist a single mountainous mass tending to produce a sensible deviation of the plumb-line. In the southern portion, indeed, between the Dniester and the Dwina, the surface is so level and so wooded that it was frequently necessary to have recourse to artificial stations, in order to obtain a clear view of the surrounding region.

M. Struve having completed the survey of Livonia in the year 1819, suggested to the University of Dorpat the desirableness of profiting by the stations of the survey, to measure the arc of the meridian of $3^\circ\ 35'$, comprised between the island of Hogland in the Gulf of Finland, and the town of Jacobstadt in Courland,—an arc passing very nearly through the meridian of the observatory of Dorpat. Through the favourable representations of that body, the sanction of the Emperor was obtained for the execution of the project, and the operations connected with it were finally completed in the year 1827. In the same year General Tenner completed the measurement of an arc of $4^\circ\ 32'$, between Bristen in Courland, and Belin in the province of Grodno, by taking advantage of the principal triangles of his operations situate in the prolongation of the Observatory of Wilna.

Bristen, the northern point of the Lithuanian arc, being situate only $4'\ 47''$ to the south of Jacobstadt, the extreme southern station

of the arc of Livonia, it obviously became desirable to unite the two partial arcs together into one complete arc. This was effected, independently, by M. Struve and General Tenner, in the years 1827–28. The results of the two geometers, accompanied by sealed letters, were submitted to the examination of the illustrious Bessel, who found them to present a most satisfactory accordance; and they were finally published in the year 1832. Thus was completed the first period in the history of the Russian arc, which at this stage of its progress extended from Hogland to Belin, and embraced an amplitude of 8° 2′·5.

The Russian Arc of the Meridian thus measured by M. Struve and General Tenner was, with two exceptions, the most extensive hitherto determined, ranking immediately after the great arc of India and the French arc. It constituted one of the ten arcs of the meridian which Bessel employed in his famous investigation of the dimensions and figure of the earth.

M. Struve did not fail soon to perceive the desirableness of extending the arc northwards, so as to form a junction with the Swedish arc measured in Lapland. Two circumstances suggested the importance of executing this operation. In the first place, it appeared that the northern arcs were not represented in sufficient fulness in Bessel's researches, although the coefficient of the ellipticity mainly depends on a comparison of such data with the arcs near the equator. Secondly, there existed some doubts respecting the Lapland arc, which tended to impair its trustworthiness as one of the elements for determining the earth's figure. This arc, as is well known, was originally measured by the French Academicians and Celsius in the year 1735; but, upon being re-measured and somewhat extended in the beginning of the present century, under the auspices of the Academy of Sciences of Stockholm, it was found that the results of the two operations assigned considerably different lengths to a degree of the meridian under the polar circle.

In 1830, M. Struve obtained the consent of the Emperor for the prolongation of the Russian arc through Finland to Tornea, the southern extremity of the Lapland arc. This undertaking was forthwith commenced, and was ultimately completed in the year 1845, M. Struve having for his principal coadjutor M. Wolstedt, now Director of the Observatory of Helsingfors, who continued during ten years to execute all the astronomical observations and all the operations connected with the measurement of the terrestrial angles, although physical obstacles of the most formidable nature constantly opposed his efforts. The length of the arc measured on this occasion was 5° 26′.

During the execution of this operation, General Tenner, by prosecuting his geodesical operations, was enabled to prolong the arc southwards to the river Dniester, which forms the northern frontier of the province of Bessarabia. This gave a further addition of 3° 18′ to the Russian arc, which now extended from Tornea, lat. 65° 50′ 34″, to Souprounkovtsi, lat. 48° 45′ 1″, and attained an amplitude of 17° 5′ 33″. In 1847, M. Struve communicated a note to the Aca-

demy of Sciences of St. Petersburg, containing the provisional results deducible from this arc, in which he announced that they seemed to indicate an enlargement of the value assigned by Bessel to the terrestrial ellipticity, viz. $\frac{1}{299{\cdot}15}$.

While the extension of the Russian arc in both directions, to which allusion has just been made, was in the course of being executed, the Imperial Government gave its sanction that the operations should be prolonged southwards as far as the River Danube, through the entire province of Bessarabia, by which an additional length of 3° 25′ would be given to the arc. This project was carried into complete effect in the year 1849, when the Russian arc finally attained a length of 20° 31′, extending from Tornea in Lapland, to Ismäil on the Danube.

The standard of linear dimensions employed in the measurement of the Russian arc had been compared with the toise of Peru by M. Arago, in the year 1821. As it was desirable that a similar comparison should be instituted between it and the standard employed in the measurement of the great arc of India, M. Struve proceeded to England in 1847, with a view to the promotion of this object. Of the two standards employed in this operation, one which Colonel Everest had brought from India was, with the sanction of the East India Company, transported to Russia, and compared directly with the standard of Pulkowa.*

In 1844, M. Struve was appointed by the Academy of Sciences of St. Petersburg to proceed to Stockholm, with the view of suggesting to the Swedish Government the expediency of prolonging the Russian arc to the Northern Ocean. This mission was attended with complete success. The measurement of the Norwegian portion of the arc was assigned to M. Hansteen of Christiania, and that of the Swedish portion to M. Selander, Director of the Observatory of Stockholm. The actual execution of the operations connected with the Norwegian arc is due to M. Klouman and M. Lindhagen, the latter of whom was detached from the Observatory of Pulkowa to assist in the undertaking. The measurement of the entire Scandinavian arc was finally completed in 1851. The Swedish arc extends from Tornea, lat. 65° 51′, to Atjick, lat. 68° 54′, and has an amplitude of 3° 3′; the Norwegian arc extends from Atjick to Fuglenaes, lat. 70° 40′, and has an amplitude of 1° 46′. The two arcs combined together have, therefore, an amplitude of 4° 49′. "It is thus," says M. Struve, "that the operations of the Scandinavian arc, commenced in 1846, have been completed in 1851. During these six consecutive years, M. Selander, associated with several assistants, has annually undergone the fatigues and perils attending a geodesical and astronomical operation, to be executed in an almost desert country, and situate between 66° and 69° of latitude. We sincerely congratulate M. Selander on the

* The Indian standard was brought back to this country in the year 1850 by M. Otto Struve, and was deposited in the hands of the Astronomer Royal, agreeably to the engagement entered into with the East India Company.

accomplishment of his arduous task; and certainly the learned world will agree with us in awarding to him the acknowledgments which are due to the execution of a scientific work of no less importance than difficulty."

The Russian and the Scandinavian arcs of the meridian now form one continuous arc,—appropriately termed by M. Struve the Russo-Scandinavian arc,—extending from Ismäil on the Danube, lat. 45° 20′, to Fuglenaes on the Northern Ocean, lat. 70° 40′, and possessing an amplitude of 25° 20′. The scientific world cannot fail to look forward with much interest to the results relative to the ellipticity of the earth deducible from the data furnished by this colossal undertaking.

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*Anleitung zur Geographischen Ortsbestimmung vorzüglich Mittels des Spiegelsextanten, von Mag. J. G. F. Bohnenberger. Neu Bearbeitet von Dr. G. A. Jahn, mit fünf tafeln Abbildungen.* Göttingen, 8vo. 1852.

In this new edition of a work, which has long enjoyed a well-merited popularity in Germany, several improvements are effected, which are calculated to adapt the work to the present advanced state of astronomical and geographical science. The portion in the original edition relating to the quadrant is entirely suppressed, and new subjects introduced in its stead; among which may be mentioned an explanation of the use of the patent reflecting circle of Pistor and Martins of Berlin, and of the portable transit instrument for the determination of latitudes by means of observations made in the prime vertical.

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## COMET (I.) 1853.

Observations of this comet, made in various places, will be found in No. 856 of the *Astronomische Nachrichten*.

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## COMET (II.) 1853.

The comet discovered by M. Schweizer on the 4th of April has been observed at Hamburgh by M. Rümker. It appeared tolerably distinct, with a nucleus and short tail. The following observation of it is given by M. Rümker, in No. 857 of the *Astronomische Nachrichten*:—

| 1853. | Hamb. M.T. h m s | Comet's R.A. ° ′ ″ | Decl. ° ′ ″ |
|---|---|---|---|
| April 16 | 13 43 48 | 306 55 48·9 | + 12 33 10·9 |

Apparent Place of Star of Comparison, *n Delphini*.

| R.A. h m s | Decl. ° ′ ″ |
|---|---|
| 20 26 59·48 | + 12 31 23·2 |

## COMET (II.) 1852.

Observations of this comet, made at the observatory of Berlin, and extending to Jan. 9, 1853, are given in the *Astronomische Nachrichten*, No. 856, p. 250.

## PSYCHE.

An ephemeris of this planet for the opposition of 1853 has been calculated by Dr. Oudemans of Leyden (*Ast. Nach.* No. 858, p. 294). It extends from April 12 to May 12.

## COMET OF ENCKE.

Observations of this comet, made at the observatory of Breslau in the year 1852, will be found in No. 858 of the *Astronomische Nachrichten.*

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